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# Low One-Year Mortality After Contemporary Laparoscopic Bariatric Surgery: An Analysis of the Bariatric Outcomes Longitudinal Database

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## BRIEF TITLE

One-Year Mortality After Bariatric Surgery

## PRECIS

The 1-year mortality rate after contemporary laparoscopic Roux-en-Y gastric bypass and laparoscopic sleeve gastrectomy is much lower than previously reported. Older age, higher body mass index, and the presence of 30-day leak and pulmonary embolus increase the odds of 1-year mortality.

## INTRODUCTION

The risk of death after bariatric surgery has been decreasing over the past two decades since the introduction of laparoscopic bariatric surgery. Early (30-day) mortality after bariatric surgery is now a relatively rare event with contemporary rates typically <0.2%. (1–4) In a study examining the mortality rate in patients who underwent bariatric surgery over an 8-year period, Nguyen and colleagues (5) reported that the in-hospital mortality rate for bariatric operations decreased from 0.4% in 2002 to 0.06% in 2009. Factors leading to reduction of mortality over time include transitioning from open to laparoscopic bariatric surgery (5, 6), initiation of laparoscopic bariatric surgery training by national societies (7), implementation of a national bariatric surgery accreditation system (8, 9), and improvement in surgeons' skills after overcoming the learning curve for bariatric surgery (10).

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DISCLOSURES
The American Society for Metabolic and Bariatric Surgery, the surgeons and the hospitals participating in the Centers of Excellence program from 2007 to 2012 are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

MEETING PRESENTATION
This research is scheduled to be presented as a "Top Paper" at the Annual Meeting of the Southern California Chapter of the American College of Surgeons in Santa Barbara, CA, January 2018. (Note—this meeting has been postponed)

Most studies examining the risk of mortality after bariatric surgery have been limited to either in-hospital or 30-day data, which may underrepresent the true risk of bariatric surgery. (11–14) In a study examining early mortality among Medicare beneficiaries who underwent open bariatric surgery between 1997–2002, Flum and colleagues (11) found that the 30-day and 1-year mortality were vastly different at 2.0% and 4.6%, respectively. In a study examining mortality after laparoscopic and open bariatric operations performed in Veterans Affairs Medical Centers, Arterburn and colleagues (12) similarly reported a high 30-day and 1-year mortality of 1.3% and 3.4%, respectively. These studies suggest that about 60% of deaths within the first year following bariatric surgery occur after 30 days, meaning the true risk of mortality after bariatric surgery may be beyond the 30-day mark and better evaluated out to one year after surgery. Additionally, the high 1-year mortality rates reported from these studies may represent outcomes from the era of open bariatric surgery. However, few studies have examined 1-year mortality after contemporary laparoscopic bariatric surgery within the past decade. (15, 16)

The Bariatric Outcomes Longitudinal Database (BOLD) was initiated in 2007 by the American Society of Metabolic and Bariatric Surgery (ASMBS) with a unique aspect of reporting of 1-year outcomes, providing the opportunity to examine 1-year mortality after contemporary laparoscopic bariatric surgery. The aim of this study was to use the BOLD to examine 30-day and 1-year mortality rates, as well as risk factors for 1-year mortality after contemporary laparoscopic bariatric surgery.

# METHODS

## Data Source

The BOLD is managed by the ASMBS and contains HIPAA-compliant, patient-level data prospectively collected from over 700 centers participating in the ASMBS Bariatric Surgery Centers of Excellence program. The ASMBS and the American College of Surgeons Bariatric Surgery Center Network merged their respective bariatric accreditation programs in 2012 to form the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP). At that time, the BOLD was discontinued and a more refined MBSAQIP database was started. However, the BOLD database was selected for use in this study because it contains data from accredited bariatric centers with 1-year outcomes after index bariatric operations, whereas MBSAQIP data are limited to 30-day outcomes.

This study was exempt from Institutional Review Board approval, as the BOLD contains only de-identified patient data and any specific patient intervention or interaction was not possible.

## Data Analysis

All patients who underwent laparoscopic Roux-en-Y gastric bypass (LRYGB) or laparoscopic sleeve gastrectomy (LSG) between 2008–2012 were examined. To control for the effect of the type of procedure on outcomes, data were analyzed separately according to whether LRYGB or LSG was performed. Open cases were excluded. The primary outcome of interest was the mortality rate within one year after a patient's index bariatric operation.

### Statistical Analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC). Multivariate logistic regression was used to determine the adjusted odds ratio (AOR) for the association between 1-year mortality and patients' demographics; comorbidities; and the presence of major complications including 30-day leak, 30-day pulmonary embolism (PE), and 30-day hemorrhage. The statistical analysis was limited to these three complications as they were the only variables available for specific complications. Other complications were grouped as a composite endpoint that included mortality, and hence could not be used in our model to determine risk factors for mortality. A parsimonious model was then obtained using backward selection of variables with $P < 0.1$ from the multivariate logistic regression model. Results were reported as AOR with 95% confidence intervals (CI). Patients with missing preoperative condition variables were excluded from the regression analysis. Two-sided tests with $P < 0.05$ were considered statistically significant.

## RESULTS

Data on 158,606 laparoscopic bariatric operations were examined, including 128,349 (80.9%) LRYGB and 30,257 (19.1%) LSG procedures. Patient demographics and comorbidities are summarized in Table 1. For patients undergoing LRYGB, mean age was 45.5 (standard deviation, SD, 11.7) years old; race was predominately Caucasian (71.8%); mean body mass index (BMI) was 47.5 (SD 8.1) kg/m$^2$; and the most common preoperative comorbidities included hypertension (54.8%), obstructive sleep apnea (43.4%), depression (36.4%), and diabetes (32.9%). For patients undergoing LSG, mean age was 44.6 (SD 11.3) years old; race was predominately Caucasian (68.3%); mean BMI was 46.4 (SD 8.6) kg/m$^2$; and the most common preoperative comorbidities included hypertension (50.4%), obstructive sleep apnea (39.7%), depression (31.7%), and diabetes (27.1%).

Outcomes after LRYGB and LSG are summarized in Table 2. For LRYGB, the 30-day mortality rate was 0.13%, and the 1-year mortality rate was 0.23%, representing a 76.9% relative increase. Among the 294 cases of 1-year mortality, 124 (42.2%) occurred between 30 days and 1 year after surgery. Postoperative rates of 30-day leak, PE, and hemorrhage were 0.45%, 0.16%, and 1.54%, respectively. For LSG, the 30-day mortality rate was 0.06%, and the 1-year mortality rate was 0.11%, representing an 83.3% relative increase. Among the 32 cases of 1-year mortality, 17 (53.1%) occurred between 30 days and 1 year after surgery. Postoperative rates of 30-day leak, PE, and hemorrhage were 0.26%, 0.11%, and 0.59%, respectively.

Table 3 lists patients' demographics, comorbidities, and the presence of 30-day complications, along with their associated odds of 1-year mortality after laparoscopic bariatric surgery after adjustment for all covariates. A parsimonious model was then obtained using backward selection of variables with $P < 0.1$ from the multivariate logistic regression model, with results as listed in Table 4. For LRYGB, significant risk factors independently associated with higher odds of 1-year mortality included older age (AOR 1.05 per year; $P < 0.001$); male gender (AOR 1.88; $P < 0.001$); higher BMI (AOR 1.04 per unit; $P < 0.001$); history of venous thromboembolism (VTE; AOR 2.04; $P = 0.006$); any functional impairment (i.e., bedridden or needing an assistance device to mobilize; AOR 1.76; $P =$

0.003); and the presence of 30-day leak (AOR 25.4; $P < 0.001$), 30-day PE (AOR 34.5; $P < 0.001$), and 30-day hemorrhage (AOR 2.34; $P = 0.001$). For LSG, significant risk factors independently associated with higher odds of 1-year mortality included older age (AOR 1.08 per year; $P < 0.001$); higher BMI (AOR 1.05 per unit; $P = 0.009$); and the presence of 30-day leak (AOR 35.8; $P < 0.001$) or 30-day PE (AOR 252.0; $P < 0.001$). For both LRYGB and LSG, the effect of substance abuse on death could not be determined, as none of the patients with a history of substance abuse died in this series.

## DISCUSSION

In this study examining the outcomes of contemporary laparoscopic bariatric surgery performed at Bariatric Surgery Centers of Excellence, we found an overall low risk of 30-day mortality (0.13% for LRYGB and 0.06% for LSG) that increased by 1.8-fold by one year (0.23% for LRYGB and 0.11% for LSG). Factors associated with higher 1-year mortality included older age; higher BMI; and the presence of 30-day leak and PE for both LRYGB and LSG. For LRYGB specifically, other factors associated with higher 1-year mortality included male gender, any functional impairment, history of VTE, and the presence of 30-day hemorrhage.

The most important finding from the current study is the low contemporary 1-year mortality rate after laparoscopic bariatric surgery, which is much lower than previously reported. Prior studies examining open and laparoscopic bariatric surgery have reported 1-year mortality rates ranging between 0.38%−4.6%. (11, 12, 15, 16) In a study of bariatric surgeries recorded in Swedish national registries between 1980–2010, Tao and colleagues (15) reported a low 1-year mortality of 0.38%. In a study examining outcome of open and laparoscopic gastric bypass in the state of California between 1995 and 2009, Weiss and colleagues (16) reported a 1-year mortality rate of 2.2%. Flum and colleagues (11) reported a 1-year mortality rate as high as 4.6% in their study on over 16,000 patients who underwent bariatric surgery from 1997–2002. The low 1-year mortality of 0.11–0.23% in the current study is likely multifactorial. One contributing factor may be the transition from open to laparoscopic bariatric surgery, which has been shown to be associated with lower mortality. (5, 6) Additionally, the implementation of training programs by national societies to minimize the learning curve of laparoscopic bariatric surgery may also account for the decreased mortality over time. (7, 10) Furthermore, the development of the bariatric surgery accreditation system may have also contributed to the reduction in mortality rates, since accredited centers in bariatric surgery have been shown to have improved outcomes compared to nonaccredited centers. (8, 9)

Our study also confirmed that limiting analysis to 30-day mortality significantly underestimates the mortality rate after laparoscopic bariatric surgery. For LRYGB, 42.2% of the mortality events within the first year of surgery occurred after 30 days. Similarly, for LSG, 53.1% of the mortality events within the first year occurred after 30 days. This is consistent with the finding that limiting analysis to 30 days after bariatric surgery excludes about 60% of mortality events that occur within the first year after surgery. (11–13) Furthermore, in a study examining mortality after bariatric surgery using a Pennsylvania statewide database, Omalu and colleagues (13) found that deaths due to traumatic causes (i.e., motor vehicle accidents, homicides, falls, suicides, drug overdoses) comprised only 10% of the mortality events recorded over a nine-year period. This suggests that the majority of deaths occurring after 30 days are due to complications of surgery or underlying comorbidities, and that evaluating 1-year mortality may provide a more accurate picture of the true risk of bariatric surgery. The higher 1-year mortality rates also suggest that patients would benefit from comprehensive, long-term follow-up, such as is required by the MBSAQIP for accreditation of bariatric centers. This calls into question the 2013 decision by Medicare to reverse the National Coverage Determination that required bariatric centers to be accredited to serve Medicare beneficiaries. Without accreditation, there is no formal, mandatory review process to ensure that Medicare patients receive long-term follow-up after bariatric surgery, which may place them at undue risk of long-term complications.

Factors associated with increased odds of 1-year mortality after LRYGB in this study include older age, male gender, and higher BMI. These findings are consistent with results from previously published studies on mortality after laparoscopic bariatric surgery (Table 5). Additionally, our study identified that a history of VTE and impaired functional status are both independently associated with higher 1-year mortality. We also found that the presence of 30-day leak, PE, and hemorrhage events were associated with increased odds of 1-year mortality after LRYGB. In a study examining the effect of short-term complications on early mortality in 580 LRYGB cases, Fernandez and colleagues (17) similarly found that the presence of postoperative leak and PE were associated with higher early mortality. The effect of postoperative hemorrhage on the risk of mortality was not assessed in that study.

Few studies have examined risk factors for mortality after LSG. In an American College of Surgeons National Surgical Quality Improvement Program (NSQIP) study, 5,871 LSG cases were used to develop a risk calculator for serious adverse events that was then validated in a series of 3,130 cases from the same database. (1) The authors found that 30-day serious adverse events were correlated with male gender (OR 1.68; 95% CI 1.03–2.72) and increased BMI (OR 1.03; 95% CI 1.01–1.05), along with various other preoperative comorbidities. In our study, which has a similar population of patients undergoing LSG, we likewise found an association between higher BMI and increased odds of 1-year mortality (AOR 1.05 per unit; $P = 0.013$). We also found that the presence of 30-day complications including leak and PE were associated with an increase in odds of 1-year mortality.

A final point to note is the discrepancy between the large number of LRYGB cases compared to LSG cases performed in the current study. One possible reason that over four times as many LRYGB cases were performed is that the learning curve for LRYGB was reaching a plateau during the study period, whereas the curve for LSG was still developing. In a study using the Nationwide Inpatient Sample from 2008–2012, a time period similar to the one used in the current study, Khan et al (18) found that the percentage of LRYGB cases increased from 58.2% of total bariatric cases in 2008 to a peak of 63.2% in 2009, and then decreased to 49.4% by 2012. In contrast, the authors showed that the percentage of LSG cases increased from 8.2% in 2011 to 39.6% in 2012. Similarly, the percentage of LRYGB cases in the current study decreased from 95.3% in 2008 to 62.6% in 2012, while the percentage of LSG cases increased from 4.7% in 2008 to 37.4% in 2012. This suggests a transition from LRYGB toward LSG over the study period, a trend that has been demonstrated in a number of other recent studies. (19–21)

There are several limitations to our study. First, this was a retrospective study based on a national database and was thus subject to possible selection bias, inaccurate data input, coding errors, and missing data. Secondly, we are unable to determine the actual cause of death and whether it was related to the index bariatric operation. Despite these limitations, this study included a large sample size from a national cohort of patients. In addition, analysis in this study was stratified by type of procedure, either LRYBG or LSG, allowing us to control for both the effect of operative approach (i.e., no open cases were analyzed that could influence our results) and the effect of procedure type. In addition, our study is one of few that have analyzed risk factors for mortality out to one year after laparoscopic bariatric surgery, allowing us to include a significant percentage of patients who are not evaluated in analyses limited to short-term outcomes.

## CONCLUSION

The risk of 1-year mortality after contemporary laparoscopic bariatric surgery is much lower than previously reported, likely due to overcoming the learning curve of laparoscopic surgery, the development of specialized bariatric training programs, and the establishment of an accreditation program for bariatric surgery. It is important to continually refine surgical techniques and perioperative management in order to minimize leaks and pulmonary emboli after laparoscopic bariatric surgery, as these complications increase the risk for mortality. In addition, limiting the analysis of mortality to a 30-day endpoint may underrepresent the true risk of mortality after laparoscopic bariatric surgery. Future studies should consider using 1-year mortality as a more meaningful and accurate endpoint for analysis of outcomes after laparoscopic bariatric surgery.

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## ABBREVIATIONS

| | |
|---|---|
| **AOR** | adjusted odds ratio |
| **ASMBS** | American Society of Metabolic and Bariatric Surgery |
| **BMI** | body mass index |
| **BOLD** | Bariatric Outcomes Longitudinal Database |
| **LRYGB** | laparoscopic Roux-en-Y gastric bypass |
| **LSG** | laparoscopic sleeve gastrectomy |

| | |
|---|---|
| **MBSAQIP** | Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program |
| **NSQIP** | National Surgical Quality Improvement Program |
| **PE** | pulmonary embolism |
| **VTE** | venous thromboembolism |

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**Table 1.**

Patient Demographics and Characteristics According to Type of Procedure

| Characteristic | LRYGB (n = 128,349) | LSG (n = 30,257) |
|---|---|---|
| Age, y, mean (SD) | 45.5 (11.7) | 44.6(11.3) |
| Age, y, median (IQR) | 45.0 (37–54) | 44.0 (36–53) |
| Female sex, n (%) | 57,944 (77.5) | 13,757 (75.2) |
| **Race, n (%)** | | |
| Caucasian | 92,111 (71.8) | 20,675 (68.3) |
| Hispanic | 10,879 (8.48) | 2,959 (9.78) |
| African American | 14,841 (11.6) | 3,748 (12.4) |
| Other | 10,518 (8.19) | 2,875 (9.50) |
| BMI, m/kg$^2$, mean (SD) | 47.5 (8.10) | 46.4 (8.60) |
| BMI, m/kg$^2$, median (IQR) | 46.0 (41.7–51.7) | 44.7 (40.4–50.7) |
| **ASA Class, n (%)** | | |
| I | 3,512 (2.74) | 996 (3.29) |
| II | 27,989 (21.8) | 8,828 (29.2) |
| III | 91,150 (71.0) | 19,548 (64.6) |
| IV | 5,698 (4.44) | 885 (2.92) |
| **Comorbidities** | | |
| Congestive heart disease | 2,560 (2.01) | 440 (1.47) |
| Depression | 46,452 (36.4) | 9,516 (31.7) |
| Diabetes | 41,958 (32.9) | 8,134 (27.1) |
| Hypertension | 69,831 (54.8) | 15,122 (50.4) |
| Ischemic heart disease | 3,511 (2.75) | 622 (2.07) |
| Liver disease | 9,020 (7.07) | 1,654 (5.51) |
| Sleep apnea | 55,378 (43.4) | 11,916 (39.7) |
| Peripheral vascular disease | 1,432 (1.12) | 278 (0.93) |
| Venous thromboembolism | 2,346 (1.83) | 435 (1.44) |
| Any functional impairment | 4,351 (3.41) | 672 (2.24) |
| Alcohol use | 17,597 (13.8) | 5,469 (18.2) |
| Tobacco use | 6,196 (4.86) | 1,494 (4.98) |
| Substance abuse | 383 (0.30) | 75 (0.25) |

Values are presented as frequencies (%) unless otherwise indicated.

ASA, American Society of Anesthesiologists; IQR, interquartile range; LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG, laparoscopic sleeve gastrectomy.

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**Table 2.**

Operative Outcomes According to Type of Procedure

| Outcome | LRYGB (n = 128,349) | | LSG (n = 30,257) | |
|---|---|---|---|---|
| | n | % | n | % |
| 30-d Leak | 575 | (0.45) | 80 | (0.26) |
| 30-d Pulmonary embolus | 208 | (0.16) | 33 | (0.11) |
| 30-d Hemorrhage | 1,979 | (1.54) | 179 | (0.59) |
| 30-d Mortality | 170 | (0.13) | 17 | (0.06) |
| 1-y Mortality | 294 | (0.23) | 32 | (0.11) |

Values are presented as frequencies (%) unless otherwise indicated.

LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG, laparoscopic sleeve gastrectomy

**Table 3.**

Factors Predictive of 1-Year Mortality after Laparoscopic Bariatric Surgery According to Type of Procedure, Multivariate Logistic Regression Model

| Variable | LRYGB | | | LSG | | |
|---|---|---|---|---|---|---|
| | AOR | 95% CI | p value | AOR | 95% CI | p value |
| Age, per 1-year increase | 1.05 | (1.04, 1.07) | <0.001 | 1.08 | (1.04, 1.13) | <0.001 |
| Male gender (ref: Female) | 1.93 | (1.50, 2.48) | <0.001 | 1.39 | (0.63, 3.06) | 0.416 |
| **Race (ref: Caucasian)** | | | | | | |
| Hispanic | 1.16 | (0.71, 1.88) | 0.554 | 0.67 | (0.09, 5.21) | 0.703 |
| African American | 1.28 | (0.89, 1.86) | 0.184 | 2.08 | (0.74, 5.82) | 0.163 |
| Other | 1.22 | (0.79, 1.86) | 0.368 | 0.89 | (0.23, 3.46) | 0.865 |
| BMI, per 1-unit increase | 1.04 | (1.03, 1.05) | <0.001 | 1.05 | (1.01, 1.08) | 0.013 |
| **ASA Class (ref: Class I)** | | | | | | |
| II | 0.69 | (0.29, 1.66) | 0.409 | 0.24 | (0.04, 1.36) | 0.106 |
| III | 0.81 | (0.35, 1.84) | 0.610 | 0.21 | (0.04, 0.99) | 0.048 |
| IV | 1.67 | (0.70, 4.02) | 0.249 | 2.34 | (0.46, 11.7) | 0.304 |
| **Comorbidities (ref: absence of comorbidity)** | | | | | | |
| Congestive heart disease | 1.25 | (0.72, 2.16) | 0.431 | 0.67 | (0.08, 5.57) | 0.713 |
| Depression | 1.09 | (0.85, 1.39) | 0.523 | 1.07 | (0.47, 2.44) | 0.868 |
| Diabetes | 0.91 | (0.70, 1.18) | 0.478 | 0.68 | (0.29, 1.59) | 0.379 |
| Hypertension | 1.29 | (0.98, 1.69) | 0.067 | 1.36 | (0.58, 3.18) | 0.477 |
| Ischemic heart disease | 0.95 | (0.56, 1.60) | 0.846 | 2.74 | (0.77, 9.75) | 0.120 |
| Liver disease | 0.82 | (0.50, 1.35) | 0.438 | 2.88 | (0.95, 8.77) | 0.062 |
| Sleep apnea | 1.09 | (0.85, 1.39) | 0.500 | 1.00 | (0.45, 2.18) | 0.989 |
| Peripheral vascular disease | 1.28 | (0.61, 2.67) | 0.512 | 0.88 | (0.09, 8.27) | 0.913 |
| Venous thromboembolism | 2.00 | (1.19, 3.34) | 0.008 | 0.88 | (0.09, 7.42) | 0.844 |
| Any functional impairment | 1.71 | (1.17, 2.50) | 0.005 | 1.07 | (0.28. 4.05) | 0.922 |
| Alcohol use | 0.81 | (0.56, 1.18) | 0.276 | 1.10 | (0.40, 3.04) | 0.852 |
| Tobacco use | 1.47 | (0.90, 2.41) | 0.126 | 1.95 | (0.44, 8.57) | 0.375 |
| **Complications, 30d (ref: no complication)** | | | | | | |
| Leak | 24.67 | (16.7, 36.6) | <0.001 | 37.25 | (8.50, 163.2) | <0.001 |
| Pulmonary embolus | 33.73 | (20.5, 55.7) | <0.001 | 233.5 | (60.4, 901.9) | <0.001 |
| Hemorrhage | 2.30 | (1.37, 3.86) | 0.002 | 6.47 | (1.05, 39.7) | 0.044 |

AOR, adjusted odds ratio; ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG, laparoscopic sleeve gastrectomy; ref, reference

## Table 4.

Factors Predictive of 1-Year Mortality after Laparoscopic Bariatric Surgery According to Type of Procedure, Parsimonious Model*

| Variable | LRYGB | | | LSG | | |
|---|---|---|---|---|---|---|
| | AOR | 95% CI | p-value | AOR | 95% CI | p-value |
| Age, per 1-year increase | 1.05 | (1.04, 1.07) | <0.001 | 1.08 | (1.04, 1.13) | <0.001 |
| Male gender (ref: Female) | 1.88 | (1.48, 2.40) | <0.001 | -- | -- | -- |
| BMI, per 1-unit increase | 1.04 | (1.03, 1.05) | <0.001 | 1.05 | (1.01, 1.08) | 0.009 |
| ASA Class III | | | | | | |
| **Comorbidities (ref: absence of comorbidity)** | | | | | | |
| Hypertension | 1.29 | (1.00, 1.66) | 0.050 | -- | -- | -- |
| Liver disease | -- | -- | -- | 2.88 | (0.98, 8.50) | 0.055 |
| Venous thromboembolism | 2.04 | (1.23, 3.38) | 0.006 | -- | -- | -- |
| Functional status--any impairment | 1.76 | (1.21, 2.56) | 0.003 | -- | -- | -- |
| **Complications, 30d (ref: no complication)** | | | | | | |
| Leak | 25.4 | (17.2, 37.5) | <0.001 | 35.8 | (8.61, 157.3) | <0.001 |
| Pulmonary embolism | 34.5 | (20.9, 56.8) | <0.001 | 252 | (71.0, 895.2) | <0.001 |
| Hemorrhage | 2.34 | (1.39, 3.92) | 0.001 | 5.24 | (0.88, 31.4) | 0.070 |

*Parsimonious model was obtained using backward selection of variables with $P < 0.1$ from the multivariate logistic regression model

AOR, adjusted odds ratio; ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG, laparoscopic sleeve gastrectomy; PE, pulmonary embolism; ref, reference

**Table 5.**

Summary of Selected Studies Published over the Last Decade Examining Risk Factors for Mortality After Laparoscopic Roux-en-Y Gastric Bypass and/or Laparoscopic Sleeve Gastrectomy

| Procedure, article | Database | Groups Studied | Group size n | Mortality rate, % (follow-up time) | Risk factors for mortality |
|---|---|---|---|---|---|
| **LRYGB or LSG analyzed as separate groups** | | | | | |
| Current Study | BOLD 2008–2012 | LRYGB<br>LSG | N = 128,349<br>N = 30,257 | 0.23% (1 y)<br>0.11% (1 y) | Both: older age, higher BMI, 30-d leak, 30-day PE, 30-day hemorrhage<br>LRYGB only: male gender, history of VTE, decreased functional status |
| Morton 2014 (22) | BOLD 2007–2010 | LRYGB | N = 51,788 | 0.1% (30 d) | Age ≥ 50; male gender; BMI 50–70; comorbidities ≥ 5; LOS 0, 0/1, or 4 |
| Aminian 2015 (1) | NSQIP 2012 | LSG | N = 5871 | 0.05% (30 d) | Male sex, higher BMI, CHF, chronic steroid use, DM, preoperative serum total bilirubin level, preoperative hematocrit level |
| **LRYGB or LSG analyzed in combination with other bariatric procedures** | | | | | |
| Morino 2007 (23) | SICOB Registry 1996–2006 | LRYGB+ ORYGB | N = 1106 | 0.54% (60 d) | Laparoscopic-to-open conversion, HTN |
| Arterburn 2009 (12) | VAMC NSQIP 2000–2006 | LRYGB + ORYGB + LAGB+ OAGB + LSG + VBG + OSG + other | N = 856 | 1.3% (30 d)<br>2.1% (90 d)<br>3.4% (1 y) | BMI ≥ 50, Diagnostic Cost Group score ≥ 2, open approach |
| Nguyen 2011 (24) | NIS 2006–2008 | LRYGB + ORYGB + LAGB + VBG | N = 304,515 | 0.12% (inpatient) | Age > 50, male gender, CHF, CRF, PVD, open vs. laparoscopic approach, gastric bypass vs. other bariatric procedures |
| Dorman 2012 (25) | NSQIP 2005–2009 | LRYGB + ORYGB + LAGB + VBG + BPD-DS | Laparoscopic: N = 43,361<br>Open: N = 5,017 | 0.15% (30 d) | Laparoscopic bariatric procedures only: BMI ≥ 60, male gender, DM, cardiac comorbidities<br>Open bariatric procedures only: BMI ≥ 60 |
| Ramanan 2012 (26) | NSQIP 2006–2008 | LRYGB + ORYGB + LAGB + VBG + BPD-DS + other | N = 21,891 | 0.14% (30 d) | Older age, higher BMI, PVD, dyspnea, previous PCI, chronic steroid use, type of bariatric procedure |
| Khan 2013 (27) | NSQIP 2007–2009 | LRYGB + ORYGB + LAGB + VBG + BPD-DS | N = 44,408 | 0.14% (30 d) | Age > 45, BMI > 50, male gender, DM, totally dependent functional status, PCI, dyspnea, >10% weight loss in 6 mo, bleeding disorder, open vs. laparoscopic approach |
| Nguyen 2013 (28) | UHC database 2002–2009 | LRYGB + ORYGB + LAGB + VBG | N = 105,287 | 0.17% (inpatient) | Age > 60, male gender, Medicare payer, DM, open approach, gastric bypass vs. nongastric bypass bariatric procedure |
| Benotti 2014 (3) | BOLD 2007–2011 | LRYGB+ ORYGB | N = 81,751 | 0.15% (30 d) | Older age, male gender, higher BMI, pulmonary HTN, CHF, liver disease |

| **Procedure, article** | **Database** | **Groups Studied** | **Group size n** | **Mortality rate, % (follow-up time)** | **Risk factors for mortality** |
|---|---|---|---|---|---|
| Tao 2015 (15) | Swedish Patient Registry 1980–2010 | LRYGB + ORYGB + LAGB + VBG + BPD-DS + other | N = 22,487 | 0.38% (1 y) | Male gender, CHF, DM, open approach |
| Telem 2015 (29) | SPARCS 1999–2005 | LRYGB + LAGB + VBG + sleeve gastrectomy | N = 7862 | 2.5% (8–14 y) | Older age, male gender, Medicare/ Medicaid payment source, CHF, HTN, DM, chronic pulmonary disorder, rheumatoid arthritis |
| Lazzati 2016 (4) | French National Health Service Database 2007–2012 | LRYGB + ORYGB + LAGB + OAGB + LSG + OSG | N = 133,804 | 0.12% (90 d) | Age >50, BMI > 50, male gender, DM, HTN, open approach, procedure type, lower procedure volume |
| Weiss 2016 (16) | California OSHPD 1995–2009 | LRYGB + ORYGB | N = 129,432 | 2.2% (1 y); 4.4% (5 y); 8.1% (10 y) | Older age, male gender, open approach, DM, smoker, alcohol abuse, higher Charlson Index, insurance status, LOS < 4 or ≥ 7 |

ASA, American Society of Anesthesiologists; BMI, body mass index; BOLD, Bariatric Outcomes Longitudinal Database; CAD, coronary artery disease; CHF, congestive heart failure; CRF, chronic renal failure; DM, diabetes mellitus; HTN, hypertension; LAGB, laparoscopic adjustable gastric banding; LOS, length of stay; LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG, laparoscopic sleeve gastrectomy; NIS, National Inpatient Sample; NSQIP, National Surgical Quality Improvement Program; OAGB, open adjustable gastric banding; ORYGB, open Roux-en-Y gastric bypass; OS-MRS, Obesity Surgery Mortality Risk Score; OSG, open sleeve gastrectomy; OSHPD, Office of Statewide Health Planning and Development; PCI, percutaneous coronary intervention; PE, pulmonary embolus; PVD, peripheral vascular disease; SICOB, Italian Society of Obesity Surgery; SPARCS, New York Statewide Planning and Research Cooperative System; UHC, University HealthSystem Consortium; VAMC, Veterans Affairs Medical Centers; VBG, vertical banded gastroplasty; VTE, venous thromboembolism